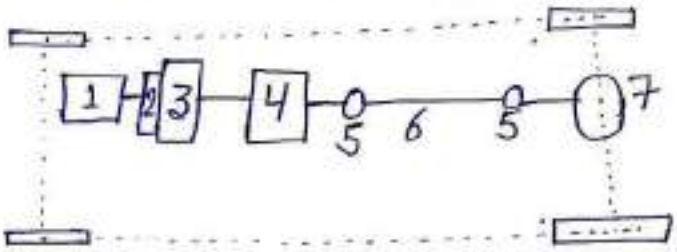
Mod-II Transmission System

Que→1 Draw a layout for a 2-wheel and 4-wheel transmission system.

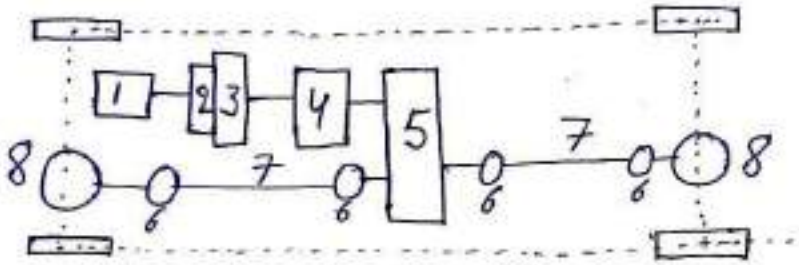
Sol^n→

For 2-wheel transmission:



1→ Engine
2→ Flywheel
3→ Clutch
4→ Gear box
5→ Universal joint
6→ Propelled shaft
7→ Differential assembly

For 4-wheel transmission:



1 → Engine
2 → Flywheel
3 → Clutch
4 → Gear box
5→ Transfer box
6→ Universal Joints
7→ Propeller Shafts
8→ Differential assembly

Que→2 Types of clutch, their advantages and disadvantages

Sol^n→ Go through book, Automobile Engg, Vol-1, Dr. Kirpal Singh page no. 30, 33, 46, 48 and 49

Que→3 What is clutch overhaul?

Sol^n→ Dr. Kirpal Singh, page no. 64

Que→4 Explain the need of having transmission box (Gear box).

Sol^n→

i) Gear box is a type of system transfering the power which is positive type of drive.
ii) To provide the torque required for different road conditions.
iii) To vary the speed of a vehicle.
iv) It also able to provide reverse direction motion

Que→5 Classify different transmission system use in an automobile.

Sol^n→ There are 3-types of transmission which are

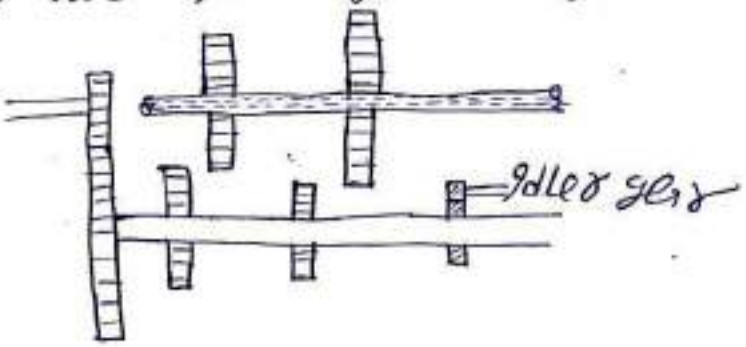
i) Manual type of transmission
   - → Sliding mesh type
   - → Constant mesh type
   - → Synchromesh type

ii) Semi-automatic type

iii) Automatic type

Que6 Explain the working of sliding mesh type of gear box.

Sol^n→ This type of transmission is of oldest method in which different gear ratios obtained by sliding gears of main shaft which is splined The gear ratio is obtained with the gear of main-shaft which is connected with counter shaft. But there is always engagement and disengagement of gears which produce sound more and limited us to use spur type of gears.



Que→7 Explain the working of Constant mesh type system.

Sol^n→ In this type of transmission, gears of main shaft are always in mesh with gears of counter-shaft. All gears of mainshaft are always rotating with different speeds but they are not rigidly fixed on the shaft so shaft doesn't rotate with the rotation of gears. Dog clutch are use to engage with desired gear so that rotation of main shaft obtained since gears are always in mesh so we can use helical gear which is efficient and produce lesser sound. But one main problem with these type of gear is that to change gear ratio, dog clutch has to get two different speeds in very less time which can be dangerous. This problem minimised by using synchromesh type of system.

Imp.
Que→8 What do you understand by term double-declutching?

Sol^n→ Dr. Kirpal Singh, page no → 81

Imp.
Que→9 What is synchromesh type of gearbox?

Sol^n→ To overcome the problem occured in sliding mesh and constant mesh this is the latest development in manual type of transmission for the smooth operation. The term 'synchro' which means 'equalisation' before engagement of the dog clutch assembly. This is acheived by a combination of arrangement which is:-

i) Gear tooth which are having external cone on one side contains external teeth.

ii) A synchronizer ring having internal cone shape comes to contact with the external cone of teeth member.

iii) A hub and sleeve arrangement in which sleeve can slide over hub (fixed on main shaft) and gets engage with the synchronizer teeth and rotation of the ring is imparted to sleeve and hub due to which shaft starts rotating.

Que→10 What are the differences between sliding mesh and Constant mesh arrangement ?

Sol^n →

	Sliding mesh type	Constant mesh type
i)	Not all the gears of main shaft engaged at a single time.	All gears are engaged with gears of Countershaft.
ii)	Spur gear arrangement more sound.	lesser sound as provision of helical gear.
iii)	Less efficient	efficient

Que→11 What is the use of transfer box ? How does it works ?

Sol^n → Dr. Kirpal Singh, page no → 94.

Que→12 What is automatic transmission ? How does it works ?

Sol^n → PDF note, Que→12

Que→13 What are the difference between manual and automatic type of transmission ?

Sol^n → Compare to manual transmission, automatic type has following advantages:

i) Less skill requirement for driver
ii) Good for hilly areas
iii) No frequent maintenance requirement

But for manual, the following positiveness found

i) Less expensive to purchase
ii) Better fuel economy
iii) Better feeling for driving
iv) Good for highways.

Que→14 write short notes on following:

a) overdrive

Imp: b) Torque converter (Fluid flywheel)

c) Freewheel

Sol^n→

a) PDF note + Dr. Kirpal singh, page no.- 116

b) Dr. Kirpal singh, page no. →110

c) PDF note + Dr Kirpal singh, page no. → 108-09

Que→15 What is Continuous variable transmission (CVT)?

Sol^n→ PDF note

Que→16 What do you understand by Semi-automatic (Automated manual) transmission? Explain Dual clutch transmission mechanism.

Sol^n→ The automated manual transmission which is also known as semi-automatic transmission is an automatic gearbox which doesn't change gear automatically but provision of changing gear manually without pressing the clutch. All of the work for changing gears is done by electronic sensors, processors and actuators to engage gears based on input from driver or computer.

Dual clutch transmission

PDF note

Que → 17 Write short notes on propeller shaft used in an automobile.

Sol^n → Dr. Kirpal Singh, page no 130
For Universal Joint, refer page no 136

(*) Imp.
Que → 18 Describe with neat sketch of Hotchkiss drive and torque tube drive. What are differences?

Sol^n → Dr. Kirpal Singh, page no. 158 + 159

(*) Imp.
Que → 19 How Semi-floating type rear axle differs from full-floating type?

Sol^n → PDF notes

Que → 20 What is the need of having a good differential mechanism? How differential works?

Sol^n →
i) Drive having final reduction of gear ratios.
ii) To provide smooth operation of vehicle.
iii) Turn the power flow by 90°

How It works?
Dr. Kirpal Singh, page no. → 152

Que → 21 What is Limited Slip differential?

Sol^n → We know that bevel pinion rotates the crown wheel which enables to rotate the spider pinion but spider pinion is free to rotate so any torque provided to it equally transmitted to both sides.
one problem occur in open type of differential is that if in a condition where one wheel finds muds or slippery surface then total torque is now transmitted to this wheel because of no resistance for power flow. So other side wheel doesn't find enough torque to get traction. This problem is overcome by mounting friction plates and spring so that it able to resist the torque. This arrangement comes under Limited Slip differen

Module – III

Que→1 What do you Understand by Steering System? Describe some steering Components use in the system.

Sol^n→ To provide swivelling movement of road wheels, we should have an arrangement which comes under this mechanism. Driver apply the effort on the steering wheel as rotation and this effort is provided through steering Linkage. This allows a driver to give a desired direction of the vehicle by simply rotating the steering wheel. There are 3 types of system:-

a) Mechanical steering
b) Hydraulic steering
c) Electronic steering

In its working, driver rotates the steering wheel due to which steering column also rotates. At the end of column, a steering gearbox is attached. In the manual type of steering, rack and pinion type gearbox attached where pinion drives the rack in longitudnal direction due to which movement of track rod takes place and finally with the help of steering arm, swivelling of wheel takes place.

steering system parts

PDF notes

Que→2 What do you Understand by the term "Power Steering"? Explain any one type of the system.

Sol^n→ Due to increasing weight of vehicle and adverse road condition, only driver effort could not be enough to negotiate a turn. So we should have such an arrangement where something should be helping the driver where small effort of driver gets converted into a large force. This function comes under the term 'power Steering' which is mainly of 2 types:

a) Hydraulic power steering } PDF notes
b) Electronic power steering }

Que→3 What is wheel alignment? What are different types of angles used?

Sol^n→ To get stability and speed and their function according to our desireness we have to set the wheel at a particular arrangement which is known as wheel alignment. The various naming of angles in this geometry in which some are

a) Camber
b) Caster
c) King-pin inclination (Steering axis inclination)
d) Toe-in and Toe-out.

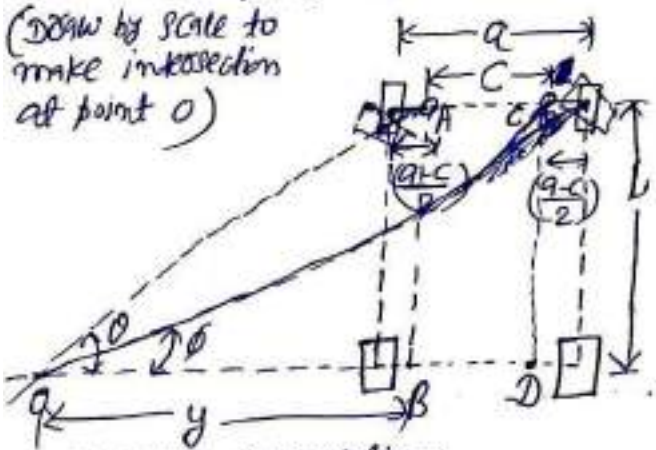
Que→4 What is camber and caster angle? Also explain Toe-in and Toe-out.

Sol^n→ wheel alignment PDF

Que→5 What do you understand by "Correct Steering" condition? Derive the formula $\cot\theta - \cot\phi = \frac{c}{l}$.

Sol^n→ The condition where we see all the wheels are in rolling condition i.e. no slippage is there this is known as correct steering condition.

(Draw by scale to make intersection at point O)



a → wheel track
l → wheel base
C → pivot center distance
θ → inner stub axle angle
φ → outer stub axle angle

ΔOAB, $\tan\theta = \frac{l}{y} \Rightarrow \cot\theta = \frac{y}{l}$

ΔOCD, $\tan\phi = \frac{l}{y+c} \Rightarrow \cot\phi = \frac{y+c}{l}$

$\Rightarrow \cot\phi = \frac{y}{l} + \frac{c}{l} \Rightarrow \cot\phi = \cot\theta + \frac{c}{l}$

$\Rightarrow \boxed{\cot\phi - \cot\theta = \frac{c}{l}}$

Radius Calculation:

$\sin\theta = \frac{l}{OA} \Rightarrow OA = \frac{l}{\sin\theta}$ ∴ Radius of front inner wheel $= \frac{l}{\sin\theta} - \frac{a-c}{2}$

Similarly, Radius of outer front wheel $= \frac{l}{\sin\phi} + \frac{a-c}{2}$

Radius of rear inner wheel $= \frac{l}{\tan\theta} - \frac{a-c}{2}$

Radius of rear outer wheel $= \frac{l}{\tan\phi} + \frac{a-c}{2}$

Que→6 Explain Charging, ignition and Starting system for an automobile.

Sol^n→ PDF of electric system in automobile.

Imp ✱ Go through each point
Types of ignition system

Que→7 What is bendix drive? Explain.

Sol^n→ PDF note

Que→8 How does a magneto works?

Sol^n→ To produce electricity, coil has to pass between the poles of the magnet. on each rotation of flywheel, an electromagnetic field is built in the coils on the armature. A cam on the electric unit create contact on the armature, disrupting the field and create electrical voltage in the primary coil. The high tension of secondary coil compared to primary coil amplifies the voltage of the current and directed to the spark plug. The cam then breaks contact with the armature and the electro-magnetic field regenerates for a new pulse of electricity. For proper functioning magneto must be installed so that firing takes place at a proper time of compression stroke.

Que→9 What is specific gravity of an battery electrolyte? On what factors it depends?

Sol^n→ Specific gravity of the battery electrolyte is the ratio of weight of solution to the weight of an equal volume of water at a specified temperature. This is the indicator of the state of the charge of a cell or battery. During the discharge, the specific gravity decreases linearly. This property of battery electrolyte depends on temperature and quantity of electrolyte in cell. with rise in temperature volume of electrolyte expands and contracts with drop in temp.
Higher Gravity ⇒ More capacity, Shorter life, less space require
Lower " ⇒ less capacity, longer life, More space required.

Numericals

A) Problems related to resistances for motion of vehicle:-

Rolling resistance = μW $\quad (W = mg)$

Air resistance = $K_a A V^2$ $\quad (K_a \rightarrow$ Aerodynamic coefficient)

Gradient resistance = $C_G W \sin\theta$ $\quad (C_G \rightarrow$ Gradient coefficient)

Total power = $F_T \times V$

$= (F_\gamma + F_a + F_G) \times V$

Que → 1 A car has mass of 1360 kg. The rolling resistance is 100 N per 1000 kg. The air resistance is given by $0.0017 AV^2$ where A is frontal area in m^2 and V is car speed in km/h. The frontal area is $2.3\ m^2$ and car speed is 47.8 km/h. Calculate the power required to propel the vehicle on a level road. If the tractive effort available at the wheel is 1860 N. Determine the maximum gradient which the vehicle can climb.

Sol^n → Rolling resistance = 100 N per 1000 kg of mass

But here mass = 1360 kg

$\therefore$ Rolling resistance $F_\gamma = 1360 \times \frac{100}{1000} = 136$ N

Aerodynamic resistance $= 0.0017\ A\ V^2$ N

(A: m^2, V: km/h)

$= 0.0017 \times 2.3 \times (47.8)^2 = 8.93$ N

$\therefore$ Total resistance in 1st case $= 136 + 8.93$

$= 144.93$ N

$\therefore$ Power required $= F_T \times V$

N × m/s = Joule/sec = Watt

$P = 144.93 \times \left(\frac{47.8 \times 1000}{3600}\right) = 1924.35$ Watt

$= 1.924$ Kw

In 2nd case,

Total available tractive effort = 1860 N

now the vehicle has to cover gradient too.

So, Total resistances = 144.93 + Gradient resistance

$\Rightarrow$ Tractive effort = $144.93 + C_G \cdot W \sin\theta$

$\Rightarrow$ $1860 = 144.93 + C_G \cdot W \sin\theta$

C_G is not given, take it as 1, $W = Mg$

$\Rightarrow$ $1860 = 144.93 + 1 \times 1360 \times 9.81 \sin\theta$

$\Rightarrow$ $\sin\theta = 0.1285$

$\Rightarrow$ $\theta = 7.383^\circ$

Que→2 A car engine has to be designed to pull the car on an inclined surface of inclination 5° at a speed of 40 km/hr in the 3rd gear. The transmission efficiency of the car in 3rd gear is 85%. The front projected area of the car is $5.3\ m^2$. If the car has self weight of 650 kg and it has to carry 5 persons in it, each of them weighing 70 kg on an average. How much power should be developed by the car? Take rolling resistance coefficient = 0.0059 and air resistance coefficient = 0.023

Sol^n→

Total Mass which is carried by engine

$= 650 + 5 \times 70 = 1000$ kg

$\theta = 5^\circ$, $V = 40$ km/hr, $C_r = 0.0059$ (or μ)

$C_a = 0.023$

$A = 5.3\ m^2$

Rolling resistance $F_r = C_r \cdot W = C_r \cdot Mg$

$= 0.0059 \times 1000 \times 9.81 = 57.88$ N

Air resistance $= C_a \cdot A V^2 = 0.023 \times 5.3 \times \left(\frac{40 \times 10}{36}\right)^2$ (A in m^2, V in m/s)

$= 15.05$ N

Gradient resistance $= C_G \cdot W \sin\theta$
$= C_G \cdot Mg \sin\theta$

take $C_G = 1$

$\therefore F_G = 1 \times 1000 \times 9.81 \sin 5^\circ$
$= 854.99\ N$

$\therefore$ Total resistances $= F_r + F_a + F_G$
$= 57.88 + 15.05 + 854.99$
$= 927.92\ N$

$\therefore$ power $= F_T \times$ Velocity
$N \times m/s = watt$

$P = 927.92 \times \left(\frac{40 \times 10}{36}\right) = 10.31\ KW$

But this power corresponds when there is no any loss in transmission.

Here transmission efficiency = 85%.

So, engine has to be develop more power for same resistances.

$\therefore P_{actual} = \frac{10.31}{0.85} = 12.13\ KW$.

Que→3 A car is going at a speed of 60 kmph when brakes were applied, it took 25 meter to stop. Determine the braking efficiency and the value of retardation. Take coefficient of friction as 0.8 between road and the tyres.

Sol^n→ actual stopping distance given = 25 m

Theoratical stopping distance will calculate based on maximum utilisation of rolling resistance.

$F_r = \mu \cdot N = \mu \cdot Mg = 0.8 \times Mg$

$\therefore$ deceleration $= \frac{F_r}{m} = \frac{0.8 \times Mg}{m} = 0.8 \times g = 8\ m/s^2$

$\therefore v^2 = u^2 + 2as \Rightarrow s = \frac{-u^2}{2a} = \frac{u^2}{2a} = \frac{\left(\frac{60 \times 1000}{3600}\right)^2}{2 \times 8}$

(minimum possible stopping dist; acce^n; deceleration) $= 17.36\ m$

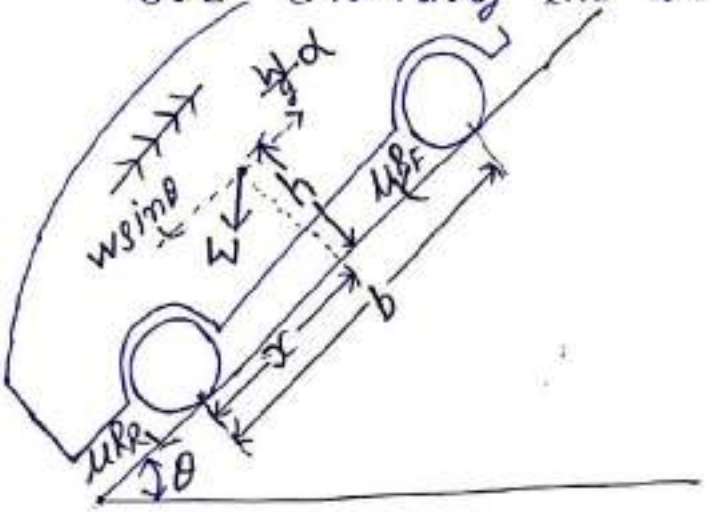
So, $\eta_b = \frac{\text{actual distance given}}{\text{actual distance given}} = \frac{17.36}{25} = 69.44\%$.

Type → B

When Brakes are applied on front wheels, Rear wheels or 4 wheels :-

	When brake is on	R_F	R_R	α/g
i)	Front wheel	$W\cos\theta\left(\frac{x}{b-\mu h}\right)$	$W\cos\theta\left(1-\frac{x}{b-\mu h}\right)$	$\frac{\mu}{W}R_F+\sin\theta$
ii)	Rear wheel	$W\cos\theta\left(\frac{x+\mu h}{b+\mu h}\right)$	$W\cos\theta\left(1-\frac{x+\mu h}{b+\mu h}\right)$	$\frac{\mu}{W}R_R+\sin\theta$
iii)	ALL 4 wheels	$W\cos\theta\left(\frac{x+\mu h}{b}\right)$	$W\cos\theta\left(1-\frac{x+\mu h}{b}\right)$	$\frac{\mu}{W}(R_F+R_R)+\sin\theta$

See carefully the terms used :



$x \rightarrow$ Distance from rear axle

$\theta \rightarrow$ positive when moving up
negative when moving down

$W = M \times g$ (not M)

$b \rightarrow$ Wheelbase

$h \rightarrow$ height of centre of gravity from inclined surface.

Que → 4 The wheelbase of a vehicle travelling on a wet road sloping upward at an angle $\theta = \sin^{-1}(0.1)$ is 5 m. Its centre of gravity is 2 m ahead of rear axle and 750 mm above the road. The coefficient of adhesion between vehicle tyre and road is 0.3. The vehicle employs brakes on all the four wheels. Determine :

a) ratio of braking forces on front and rear wheels if skidding is to be avoided

b) Stopping distance for the vehicle travelling at a speed of 45 km/hour when the engine is stopped and the brakes are applied.

Sol^n →

Given datas are

$\theta = \sin^{-1}(0.1) \Rightarrow \theta = 5.74°$

Wheelbase $b = 5\,m$

$h = 750\,mm = 0.75\,m$

$x = 2\,m$ (since directly given from rear axle)

$\mu = 0.3$

a)

since brakes has applied on all 4 wheels.

$$R_F = W\cos\theta\left(\frac{x+\mu h}{b}\right)$$

$$= W\cos\theta\left(\frac{2+0.3\times0.75}{5}\right) = 0.445\,W\cos\theta$$

$$R_R = W\cos\theta\left(1-\frac{x+\mu h}{b}\right)$$

$$= W\cos\theta\left(1-\frac{2+0.3\times0.75}{5}\right) = 0.555\,W\cos\theta$$

$$\therefore \frac{R_F}{R_R} = \frac{0.445\,W\cos\theta}{0.555\,W\cos\theta} = 0.802$$

b)

$$V = 45\ km/hr = \frac{45\times1000}{3600} = 12.5\ m/sec$$

$$\therefore \frac{\alpha}{g} = \frac{\mu}{W}(R_F + R_R) + \sin\theta$$

$$= \frac{\mu}{W}(W\cos\theta\times0.445 + W\cos\theta\times0.555) + \sin 5.74°$$

$$= \mu(\cos\theta * 0.445 + \cos\theta\times0.555) + \sin 5.74°$$

$$= \mu\cos\theta + \sin 5.74°$$

$$= 0.3\cos 5.74° + \sin 5.74°$$

$$= 0.3985$$

In book, Answer is given for taking movement of vehicle in downward slope then take θ as $(-\theta)$
$\therefore \frac{\alpha}{g} = 0.1985 \Rightarrow \alpha = 1.947$
$\therefore S \simeq 40\,m$

$$\Rightarrow \frac{\alpha}{g} = 0.3985 \Rightarrow \alpha = 0.3985\times9.81 = 3.91\ m/s^2$$

$$\therefore \text{Stopping dist } S = \frac{V^2}{2\alpha} \simeq 20\,m$$

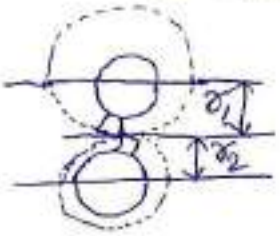
06.

Mod-II

Type→A Designing of sliding mesh Gearbox :

Take Diametral pitch = $\frac{D \rightarrow \text{pitch circle diameter}}{T \rightarrow \text{no. of teeth}}$

$\Rightarrow$ Diametral pitch = $\frac{2 \times \text{radius}}{\text{no of Teeth}}$



$r_1 = \frac{\text{dia. pitch} \times \text{Teeth}_1}{2}$

$r_2 = \frac{\text{dia. pitch} \times \text{Teeth}_2}{2}$

centre distance $r_1 + r_2 = \frac{\text{dia. pitch}}{2}(T_1 + T_2)$

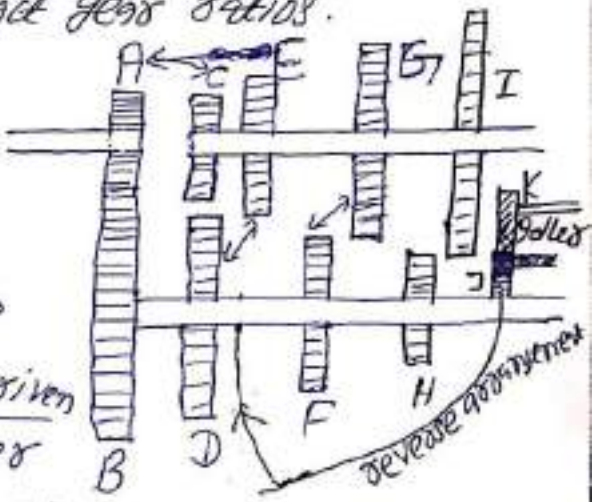
Prob→1 A four forward speed gearbox is to be prepared for gear ratios of 1.0, 1.5, 2.3 and 3.9. The diametral pitch of each gear is 3.5 mm and the smallest pinion has to be at least 12 teeth. The centre distance between main shaft and counter shaft is 63 mm. Determine the number of teeth on each gear and the exact gear ratios.

Sol^n→ Given data are :

$D_T = 3.5$ mm

Clutch gear teeth = 12

centre distance = 63 mm



$\therefore$ Gear ratio = $\frac{\text{No. of teeth on driven}}{\text{No. of teeth on driver}}$

when A and C engaged then direct gear $T_A = T_C$

when D and E engaged then Gear ratio = 1.5

$\Rightarrow 1.5 = \frac{T_B \times T_E}{T_A \times T_D} \Rightarrow 1.5 = \frac{T_B \times T_E}{12 \times T_D}$ ——→ (i)

$r_A + r_B = 63$ mm $\Rightarrow 63 = \frac{\text{dia. pitch}}{2}(T_A + T_B)$

$\Rightarrow 63 = \frac{3.5}{2}(12 + T_B) \Rightarrow T_B = 24$ teeth

$r_D + r_E = \frac{\text{dia. pitch}}{2}(T_D + T_E)$

$\Rightarrow 63 = \frac{3.5}{2}(T_D + T_E) \Rightarrow T_D + T_E = 36$ ——→ (ii)

From (i) and (ii),

$$1.5 = \frac{24 \times T_E}{12 \times T_D} \Rightarrow \frac{T_E}{T_D} = \frac{1.5}{2} \Rightarrow T_E = 0.75\,T_D$$

putting in eq^n (ii),

$$T_D + 0.75\,T_D = 36 \Rightarrow T_D = \frac{36}{1.75} = 20.57$$

Taking $T_D = 21$

$$\therefore T_E = 0.75\,T_D = 15.75$$

$$\Rightarrow T_E = 16 \text{ teeth}$$

Similarly for F and G engagement,

Gear ratio = 2.3

$$\Rightarrow 2.3 = \frac{T_B \times T_G}{T_A \times T_F} \Rightarrow 2.3 = \frac{24 \times T_G}{12 \times T_F}$$

$$\Rightarrow \frac{T_G}{T_F} = \frac{2.3}{2} \Rightarrow T_G = 1.15\,T_F \longrightarrow (iii)$$

also, $r_G + r_F = \frac{\text{dia. pitch}}{2}(T_G + T_F)$

$$\Rightarrow \frac{63 \times 2}{3.5} = T_G + T_F \Rightarrow T_G + T_F = 36 \longrightarrow (iv)$$

from (iii) and (iv)

$$\Rightarrow 1.15\,T_F + T_F = 36 \Rightarrow T_F = \frac{36}{2.15} = 16.74$$

$$\Rightarrow T_F = 17$$

$$T_G = 1.15\,T_F = 19.55 \Rightarrow T_G = 20$$

For H and I engagement,

Gear ratio = 3.9

$$\Rightarrow 3.9 = \frac{T_B \times T_I}{T_A \times T_H} \Rightarrow 3.9 = \frac{24 \times T_I}{12 \times T_H} \Rightarrow T_I = \frac{3.9}{2} T_H \longrightarrow (v)$$

and $r_H + r_I = \frac{\text{dia. pitch}}{2}(T_H + T_I) \Rightarrow T_H + T_I = 36 \longrightarrow (vi)$

from (v) and (vi), $T_I = 1.95\,T_H \Rightarrow T_H + 1.95\,T_H = 36$

$$\Rightarrow T_H = \frac{36}{2.95} = 12.20 \Rightarrow T_H = 13, \quad T_I = 1.95\,T_H = 25.35$$

$$\Rightarrow T_I = 26$$

For reverse gear, Taking C gear type as used for reverse

$\therefore T_C + 2T_K + T_J = 36$

$\Rightarrow 12 + 2T_K + T_J = 36$ $(\because T_C = T_A$ assumed$)$

$\Rightarrow 2T_K + T_J = 24$

assume $T_J = 10$ then $T_K = 7$

So, number of teeths are,

$T_A = T_C = 12$

$T_B = 24$

$T_D = 21$

$T_E = 16$

$T_F = 17$

$T_G = 20$

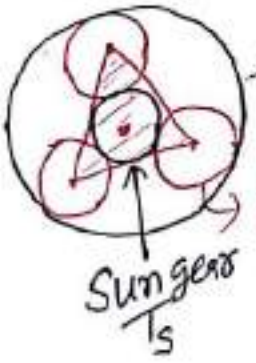
$T_H = 13$

$T_I = 26$

$T_J = 10$

$T_K = 7$

Type–B Planetary Gearset arrangement



$R_S + 2R_P = R_R$

$\Rightarrow \frac{mT_S}{2} + 2 \times \frac{mT_P}{2} = \frac{mT_R}{2}$

$\Rightarrow \boxed{T_S + 2T_P = T_R}$

Prob. In a gearbox with planetary gear operation the internal toothed ring gear has 72 teeth and sun gear has 32 teeth. How many teeth the planet gear should have? Also find gear ratio when ring gear is fixed.

Sol^n →

with the rotation of sun and planet gear, Ring gear should have rotate but it is fixed. means planet carrier is rotating itself so that net effect is zero on ring gear.

Suppose we have given x rpm clockwise to the sun gear then pinion will rotate at

$$\frac{N_S}{N_P} = -\frac{T_P}{T_S} \quad (-\text{because external engagement})$$

$$\Rightarrow \frac{x}{N_P} = -\frac{T_P}{T_S} \Rightarrow N_P = -x\frac{T_S}{T_P}$$

	N_S	N_P	N_R
when ~~planet carrier~~ ~~ring~~ gear is fixed	x	$-x\frac{T_S}{T_P}$	$-x\frac{T_S}{T_R}$
when planet carrier rotates (y clockwise)	$x+y$	$y-x\frac{T_S}{T_P}$	$y-x\frac{T_S}{T_R}$

$\left(\because \frac{N_R}{N_P} = -\frac{T_P}{T_R}\right.$ internal engagement)

$\left.\therefore N_R = N_P \times \frac{T_P}{T_R}\right.$

$= -x\frac{T_S}{T_P} \times \frac{T_P}{T_R}$

$= -x\frac{T_S}{T_R}$

we have $T_S = 32$

$T_R = 72$

and ring gear rotation = 0

$$\therefore y - x\frac{T_S}{T_R} = 0 \longrightarrow (i)$$

$\because T_S + 2T_P = T_R$

$\Rightarrow 32 + 2T_P = 72 \Rightarrow T_P = 20$

from (i), $y = x \times \frac{T_S}{T_R} \Rightarrow y = x \times \frac{32}{72} = \frac{4x}{9}$

~~from (i) Gear ratio between sun and planet~~

first find N_S and N_P

$N_S = x + y = x + \frac{4x}{9} = \frac{13x}{9}$, $N_P = \frac{4x}{9} - \frac{32x}{20}$

$= -1.56x$

$\therefore$ Gear ratio $= \frac{N_P}{N_S} = \frac{-1.56x}{13x/9} = -1.08$ (-ve because of direction so Torque ratio = 1.08)

Mod - III

④ Numerical based on Ackermann Steering :-

Internal wheel angle → θ

Outer " " → ϕ

$$\cot\phi - \cot\theta = \frac{c}{l}$$ (c is pivot centre distance)

(outer) - (inner)

Radius of front inner wheel $R_{IFW} = \frac{b}{\sin\theta} - \frac{a-c}{2}$

b → wheelbase (Sometime b is written as l so don't confuse)

$$R_{OFW} = \frac{b}{\sin\phi} + \frac{a-c}{2}$$

$$R_{IRW} = \frac{b}{\tan\theta} - \frac{a-c}{2}$$

$$R_{ORW} = \frac{b}{\tan\phi} + \frac{a-c}{2}$$

Que→ An automobile has a wheelbase of 2.743 m and pivot centre 1.065 m. The front and rear wheel track is 1.217 m. Calculate the correct angle of outside lock and turning circle radius of the front outer wheel and rear inner wheel when the angle of inside lock is 40°.

Sol→ Given datas are, $\theta = 40°$, $l = 2.743\,m$, $c = 1.065\,m$, $a = 1.217\,m$

$$\therefore \cot\phi - \cot\theta = \frac{c}{l} \Rightarrow \cot 40° - \cot\phi = \frac{1.065}{2.743}$$

$$\Rightarrow \cot\phi = \cot 40 + \frac{1.065}{2.743}$$

$$\Rightarrow \cot\phi = 1.58$$

$$\Rightarrow \tan\phi = \frac{1}{1.58} = 1.2446 \Rightarrow \phi = ?$$

$$\Rightarrow \cot\phi = 1.58 \Rightarrow \tan\phi = 0.633$$

$$\Rightarrow \phi = 32.33°$$

$$R_{OFW} = \frac{l}{\sin\phi} + \frac{a-c}{2} = \frac{2.743}{\sin 32.33°} + \frac{1.217-1.065}{2} = 5.21\,m$$

$$R_{IRW} = \frac{l}{\tan\theta} - \frac{a-c}{2} = \frac{2.743}{\tan 40} - \frac{1.217-1.065}{2} = 3.193\,m$$